PROVENANCE OF THE K/T BOUNDARY LAYERS; Hildebrand, A.R. and Boynton, W.V., Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721

An array of chemical, physical and isotopic evidence indicates that an impact into oceanic crust terminated the Cretaceous Period. Approximately 1500 km^3 of debris, dispersed by the impact fireball, fell out globally in marine and nonmarine environments producing a 2-4 mm thick layer hereafter called the fireball layer. In North American locales the fireball layer overlies a 15-25 mm thick layer of similar but distinct composition. This 15-25 mm layer, hereafter called the ejecta layer, may represent approximately 1000 km^3 of lower energy ejecta from a nearby impact site.

Isotopic and chemical evidence supports a mantle provenance for the bulk of the layers. Previous Rb-Sr and Sm-Nd isotopic investigations (1,2) found that the bulk of the fireball layer must be derived from oceanic crust and mantle, after allowing for a crustal component. Sm-Nd analyses of the fireball and ejecta layers, from a nonmarine boundary site in Alberta (see Table 1), are consistent with previous results and indicate that the fireball and ejecta layers have a similar provenance. The combination of low REE abundances and high ϵ_{Nd} values strongly indicate derivation from a depleted reservoir such as the terrestrial mantle.

We have modelled the extraordinary REE pattern of the boundary clays (3) as a mixture of oceanic crust, mantle, and approximately 10% continental material (such as a sedimentary veneer or continental fragment); Table 2 presents our results. The abundances of Ir and other siderophile trace elements in the fireball layer have been disturbed by geochemical mobilization, but the least disturbed sections indicate the projectile contributes approximately 12% of this layer. Figure 1 shows our INAA results for Ir from the Knutson's Farm locality. The Ir peak occurs in the base of the overlying coal seam which is typical of the nonmarine K/T boundary sections overlain by coal and apparently reflects Ir remobilization to the reducing coal. The proportion of the ejecta layer derived from the mantle is 73% from our REE modelling results. This fraction of mantle can provide all the Ir found in the ejecta layer (73% x .74% chondritic mantle abundance (4) x 473 ppb CI abundance (5) = 2.6 ppb Ir vs. 3.0 $\pm$ 0.5 ppb measured), suggesting that projectile material is confined to the fireball layer.

If the siderophiles of the ejecta layer were derived solely from the mantle, a test may be available to see if the siderophile element anomaly of the fireball layer had an extraterrestrial origin. Radiogenic ^{187}Os is depleted in the mantle relative to an undifferentiated chondritic source (6). We calculate $^{187}Os/^{186}Os$ ratios of 1.049 and 1.108 for the ejecta and fireball layers, respectively, based on our mixing model results (Table 2). Measuring this ratio to an accuracy of $\pm$ 0.01 will require large sample sizes, but may be within the capabilities of existing instrumentation. Also, the Os of the fireball layer has probably been thoroughly mixed with the Os of the ejecta layer by geochemical dispersion. However, sites preserving impact wave deposits like Brazos River, Texas, have apparently adequately separated boundary layers to prevent cross contamination (7). Results corresponding to our model prediction would be substantial evidence of an influx of extraterrestrial material at the K/T boundary.

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Table 1. Sm-Nd isotope systematics from a nonmarine locality

Sample	Nd (ppm)	$^{147}Sm/^{144}Nd$ ($\pm$ 0.5%)	$^{143}Nd/^{144}Nd$ ($\pm 2\sigma_m$)	ϵ^{60Ma}_{Nd} ($\pm$0.1)
SC-8 (Fireball layer)	4.385	0.1263	0.512460$\pm$6	-2.9
SC-9 (Ejecta layer)	3.847	0.1264	0.512399$\pm$5	-4.1
SC-12 (Cret. Mudstone)	17.115	0.1107	0.512278$\pm$5	-6.4
CHUR			0.512638	

Nd isotopes corrected to $^{146}Nd/^{144}Nd = 0.7219$.
Analyses performed by Dr. P.J. Patchett, Department of Geosciences, University of Arizona, on bulk samples from the Knutson's Farm K/T boundary section, Red Deer Valley, Alberta. We are grateful to Dr. J. Lerbekmo, Department of Geology, University of Alberta, for help in collecting samples.

Table 2. Provenance of the K/T boundary clay layers

	Ejecta Layer	Fireball Layer
Mantle	73%	63%
Gabbros and Cumulates	11%	10%
MORB	7%	6%
Continental Material	9%	9%
Projectile	0%	12%

Our preliminary mixing model requires a minimum excavation depth for the K/T impact crater of approximately 30 kms using enriched-type MORB. Model results using normal-type MORB require even greater excavation depths. The model requires that the mass of continental material involved exceed the mass of MORB and the overall excavation depth is sensitive to the thickness assumed for the oceanic crust.

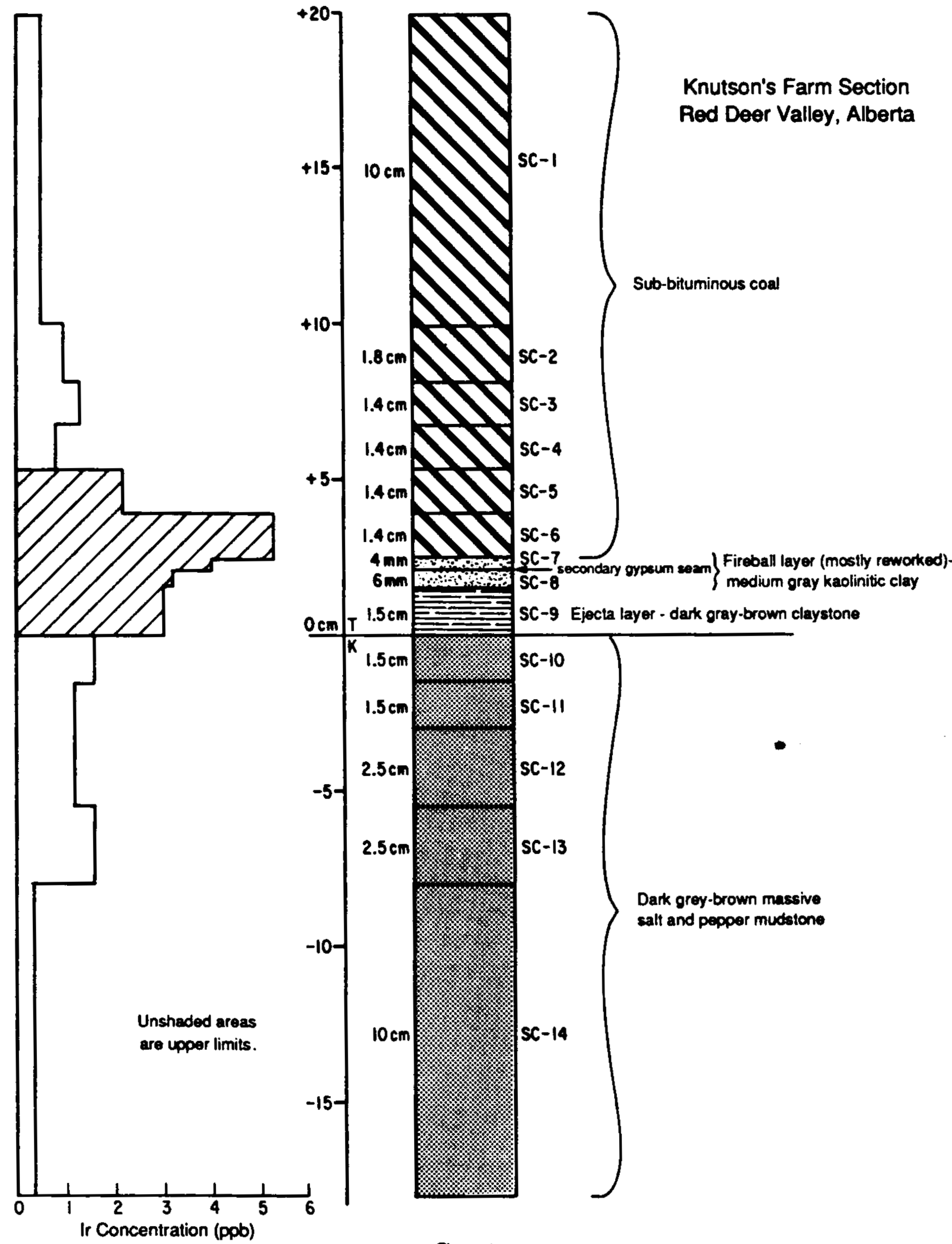

Figure 1